TITLE OF THE INVENTION

Semiconductor Cooling Device

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a cooling device for cooling semiconductor elements which generate a substantial quantity of heat and, in particular but not exclusively, to a compact, easy-to-handle and efficient cooling device for cooling such semiconductor elements by utilization of a change in phase between a liquid phase and a vapor phase of a refrigerant.

2. Description of the Related Art

Japanese Laid-Open Patent Publication No. 6-318656 discloses a cooling device for cooling integrated circuit elements, as shown in Fig. 1. The cooling device shown therein includes a condenser 12 and a refrigerant pump 13 for supplying integrated circuit elements 11 with a refrigerant. The integrated circuit elements 11, the condenser 12 and the refrigerant pump 13 are connected in series with a filter 14 interposed between the condenser 12 and the refrigerant pump 13. Japanese Laid-Open Patent Publication No. 6-318656 is silent about the kind of the refrigerant pump 13.

However, in applications where the refrigerant undergoes a phase change between a liquid phase and a vapor phase, there is a good chance that the refrigerant pump 13 may draw a vapor refrigerant or vapor of a gas-liquid refrigerant depending on the location thereof in a refrigerating cycle. In such case, the pumping power reduces or is lost in some cases, and any liquid refrigerant does not flow through a cold plate to absorb heat generated by the integrated circuit elements 11, resulting in an increase in temperature of the integrated circuit elements 11.

SUMMARY OF THE INVENTION

The present invention has been developed to overcome the

above-described disadvantages.

It is accordingly an objective of the present invention to provide a cooling device provided with a refrigerant pump capable of positively supplying a cold plate with a liquid refrigerant even if a vapor refrigerant is mixed therewith to some extent.

In accomplishing the above and other objectives, the semiconductor cooling device according to the present invention includes a cold plate for cooling a semiconductor element, a condenser, and a positive-displacement refrigerant pump. The cold plate, condenser and refrigerant pump are fluid connected in series with each other to define a refrigerating cycle.

Because a positive-displacement pump that can withstand an undesired operation in which vapor is entrapped therein is used as the refrigerant pump, the liquid refrigerant is positively supplied to the cold plate, making it possible to ensure a highly efficient refrigerating cycle.

Alternatively, a centrifugal refrigerant pump can be used in place of the positive-displacement refrigerant pump. In this case, it is preferred that a receiver tank be interposed between the condenser and the refrigerant pump. The receiver tank acts to accumulate the vapor refrigerant therein and to supply the centrifugal refrigerant pump with the liquid refrigerant, which is in turn supplied to the cold plate, making it possible to provide a highly efficient refrigerating cycle.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objectives and features of the present invention will become more apparent from the following description of preferred embodiments thereof with reference to the accompanying drawings, throughout which like parts are designated by like reference numerals, and wherein:

Fig. 1 is a refrigerating cycle of a conventional cooling device;

Fig. 2 is a refrigerating cycle of a semiconductor cooling device

according to a first embodiment of the present invention; and

Fig. 3 is a refrigerating cycle of a semiconductor cooling device according to a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

This application is based on an application No. 2003-164985 filed June 10, 2003 in Japan, the content of which is herein expressly incorporated by reference in its entirety.

Fig. 2 depicts a refrigerating cycle of a semiconductor cooling device according to a first embodiment of the present invention. The semiconductor cooling device shown in Fig. 2 includes a cold plate 1 for cooling a highly exothermic semiconductor element or elements that tend to emit a substantial amount of heat when in operation, a condenser 2, and a positive-displacement refrigerant pump 3, all connected in series with each other to define a refrigerating cycle. An outlet of the condenser 2 and an inlet of the cold plate 1 are connected via piping 5 with the refrigerant pump 3 interposed therebetween, while an outlet of the cold plate 1 and an inlet of the condenser 2 are connected via piping 6.

A refrigerant is filled in this refrigerating cycle. The condenser 2 is adapted to be cooled by a fan 4.

The cooling device is so designed that a liquid refrigerant emerging first from the condenser 2 is supplied towards the cold plate 1 through the piping 5 by the refrigerant pump 3. The cold plate 1 so supplied with the refrigerant absorbs heat generated by the highly exothermic semiconductor element and; in the course of absorption of the heat, a change in phase from the liquid refrigerant to a vapor refrigerant takes place within the cold plate 1. The vapor refrigerant is then supplied to the condenser 2 that is then cooled by the fan 4 so that the vapor refrigerant within the condenser 2 undergoes a phase change to a liquid refrigerant.

According to this embodiment, since a positive-displacement pump is

used as the refrigerant pump 3, even if a vapor component is contained in the refrigerant supplied thereto from the condenser 2, the refrigerant pump 3 can positively supply the cold plate 1 with the liquid refrigerant, making it possible to suppress an increase in temperature of the semiconductor element.

Fig. 3 depicts a refrigerating cycle of a semiconductor cooling device according to a second embodiment of the present invention. The semiconductor cooling device shown in Fig. 3 includes a cold plate 1 for cooling a highly exothermic semiconductor element or elements, a condenser 2, a receiver tank 7, and a centrifugal refrigerant pump 3, all connected in series with each other to define a refrigerating cycle. An outlet of the condenser 2 and an inlet of the cold plate 1 are connected via piping 5 with the receiver tank 7 and the refrigerant pump 3 interposed therebetween, while an outlet of the cold plate 1 and an inlet of the condenser 2 are connected via piping 6.

A refrigerant is filled in this refrigerating cycle. The condenser 2 is adapted to be cooled by a fan 4.

The cooling device is so designed that a liquid refrigerant and a vapor refrigerant emerging from the condenser 2 are first accumulated in the receiver tank 7, and only the liquid refrigerant is then supplied towards the cold plate 1 through the piping 5 by the centrifugal refrigerant pump 3. The cold plate 1 so supplied with the liquid refrigerant absorbs heat generated by the highly exothermic semiconductor element and, in the course of absorption of the heat, a change in phase from the liquid refrigerant to a vapor refrigerant takes place within the cold plate 1. The vapor refrigerant is then supplied to the condenser 2 that is then cooled by the fan 4 so that the vapor refrigerant within the condenser 2 undergoes a phase change to a liquid refrigerant.

According to this embodiment, since the receiver tank 7 and the centrifugal refrigerant pump 3 are provided in the refrigerating cycle, even if a vapor

component is contained in the refrigerant supplied from the condenser 2, only the liquid refrigerant is supplied to the centrifugal refrigerant pump 3 with the vapor refrigerant remained within the receiver tank 7. Accordingly, the liquid refrigerant can be positively supplied to the cold plate 1, making it possible to suppress an increase in temperature of the semiconductor element.

Although the present invention has been fully described by way of examples with reference to the accompanying drawings, it is to be noted here that various changes and modifications will be apparent to those skilled in the art. Therefore, unless such changes and modifications otherwise depart from the spirit and scope of the present invention, they should be construed as being included therein.